A preliminary study of the spider communities of Isla Isabela (Galapagos archipelago, Ecuador)

L. Baert, J.-P. Maelfait & K. Desander

Koninklijk Belgisch Instituut voor Natuurwetenschappen, Vautierstraat 29, B-1040 Brussels. BELGIUM.

Résumé. - Nous pouvons, à partir d'une analyse écologique de la faune aranéologique présente le long de gradients altitudinales des cinq volcans majeures de l'isle Isabela (Galápagos), conclure que la composition et les variations de cette faune sont influencées par l'âge de ces volcans, la zonation de la végétation (ou l'absence de celle-ci) et de la présence de colonies humaines et agricoles.

Abstract. - From an ecological analysis of the spider fauna occurring along altitudinal gradients of the five major volcanoes of Isla Isabela (Galápagos) we can conclude that the composition and variations of that fauna are influenced by the age of the volcanoes, the zonation of the vegetation (or absence of that) and the presence of human settlements and agriculture.

Contribution no.   of the Charles Darwin Research Foundation.

Introduction

In a previous ecological analysis of the spider fauna of Isla Santa Cruz (Galápagos archipelago) (BAERT et al.,1989c; BAERT et al., submitted paper) we found a clearly pronounced segregation between the spider faunas of the different vegetation zones of that island.
The aim of this study is to find out if a segregation in spider faunas according to altitude and habitat type also occurs on the volcanoes of isla Isabela, and if it is comparable to that of isla Santa Cruz. Whereas the vegetation of Santa Cruz has been studied in detail, this is not the case for the Isabela volcanoes. This makes a comparison of our results with the recognized vegetation zones nearly impossible.

Study area

The island Isabela has a surface of 4588km² and is formed by junction of six large shield volcanoes connected by barren lava flows at lower elevation, two southern (Cerro Azul (alt. c.1650m) and Sierra Negra (alt. c.1200m)), and four northern (Alcedo (alt. c.1200m), Darwin (alt. c.1350m), Wolf (alt. c.1700m) and Ecuador (alt. 808m)). Nearly half of the surface of the island is covered with lava flows of recent origin, either barren or sparsely vegetated.

The southern and northern volcanoes are completely isolated from each other by the Perry isthmus, a barren lava flow of some kilometers wide. For a survey description of the plant communities of the volcanoes Cerro Azul, Sierra Negra, Alcedo and Darwin we refer to HAMANN(1981).

Methods

The five major volcanoes were sampled along an altitudinal gradient from the coast to the summit : ESE slope of Cerro Azul, 11 sampling sites; SW slope of Sierra Negra, 12 sampling sites; NW slope of Alcedo, 12 sampling sites; SE flank of Darwin, 16 sampling sites and SE flank of Wolf, 12 sampling sites. Samples were taken at different altitudes by means of hand catchings (on each site with three collectors, each during 30') and pitfall traps (at the most for two days). For a detailed description of the sampling sites we refer to BAERT & MAELFAIT (1986) and BAERT et al. (1989a, 1989b). On the whole 63 localities were sampled.
An ordination technique (Detrended Correspondace Analysis or DCA) as well as a divisive classification technique (Two Way INdicator SPecies ANalysis or TWINSPAN) were applied for the analysis of our data. The programms Decorana (Hill,1979a) and Twinspan (Hill,1979b) were used as software.
For our analysis we only took into account the species caught by more than three specimens (55 species), this to avoid accidental species. Moreover the analysis is based upon presence or absence of the species and not upon absolute data.

Results

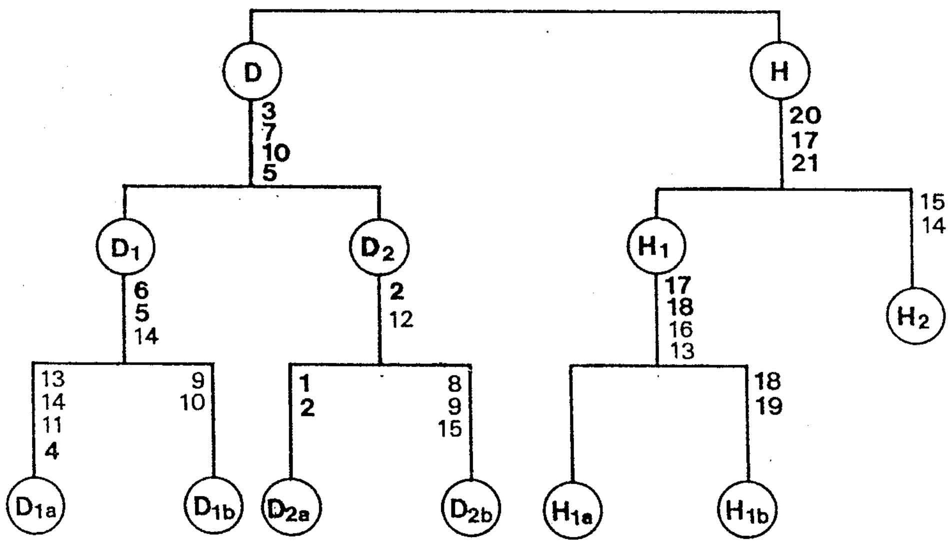
On all Isabela sampling sites together 73 spider species were caught (17 on Cerro Azul, 41 on Sierra Negra, 26 on Alcedo, 41 on Darwin and 39 on Wolf). This approximates the number caught on Santa Cruz (78) (Isabela + Santa Cruz = 91 species). Both islands have 60 species (nearly 66%) in common; 13 species were only caught on Isabela while 18 only on Santa Cruz.

Segregation of the sampling sites based on their spider fauna

As a clear segregation of the Santa Cruz sampling sites, coinciding with the known vegetation zones was obtained in a former survey (BAERT et al., submitted paper), we included the Isabela data set in the Santa Cruz data set (for a detailed description of the Santa Cruz sampling sites we refer to BAERT & MAELFAIT,1986, BAERT et al. 1989a,1989b and Baert et al., submitted paper) and submitted these data to a DCA and TWINSPAN analysis to see how the Isabela sampling sites would behave compared to the Santa Cruz sampling sites. The analysis was performed on 55 species (caught with more than three specimens) distributed over 98 sampled sites.
The Detrended Component Analysis (DCA) resulted in an ordination (first axis against second axis, together accounting for 64% of the total variation) showing along the first axis a gradient from humid to dry habitats and along the second axis a separation of natural against disturbed sites (by man, giant tortoises).

The classification of habitats of spiders, as interpreted from TWINSPAN end groups, is given in Fig. 1, together with the indicator species at each division. The indicator species given in bold characters occur in more than one end group or are defined at more than one division level by the analysis. For example : Lycos spec. C (n° 14) is a lycosid species typical for coastal lagoons (end group D1a) but can occur in higher zones (end group H2 ,but only on Santa Cruz) during wet years. The other indicator species are confined to specific habitats (end groups). Seven end groups were recognized in the following dichotomous hierarchy (Fig. 1):

Fig. 1. : Classification of habitats of spiders as interpreted from TWINSPAN end groups together with the indicator species at each division (the number refer to the species list of Table 1.)



HUMID HABITATS (H): Indicator species are <u>Coryssocnemis conica</u>, <u>Neocautinella ochoai</u> (species endemic to the Galápagos archipelago) and <u>Notiohyphantes excelsa</u> (native species also occurring on the American mainland).

Group H1 with as indicator species : <u>Coryssocnemis conica</u>, <u>Laminacauda dentichelis</u>, <u>Leucauge bituberculata</u> (endemics) and <u>Coleosoma floridanum</u> (native).

1° End group H1a : comprising the localities situated in a semi-arid zone which seems to be typical for the youngest Isabela volcanoes Cerro Azul (alt. 450-1200m) and Wolf (alt. 600-1200m); seems to correspond faunistically to the semi-open semi-dry deciduous forest of the northern flank of Santa Cruz (alt. 300-350m); it also comprises the rim of Alcedo and the entrance of a lava tunnel of Darwin (1200m). No species occurred regularly enough to act as a significant indicator.

2° End group **H1b** : comprising the localities situated in the humid pampa (fern-sedge zone) typical for the summit of Santa Cruz and Sierra Negra and in the Scalesia and Miconia zones of Santa Cruz, with Laminicauda dentichelis (endemic) and Lycos spec D (native) as indicator species.

3° End group H2 : comprising the Transition and Culture zones of Santa Cruz and the farm zone of Volcàn Sierra Negra, mainly sites which are strongly influenced by human agricultural activities, with Meioneta galapagosensis and Lycos spec C (endemics) as indicator species.

DRY AND COASTAL HABITATS **(D)** : Indicator species are Theridion coldoniae, Neoscona cooksoni (both endemics), Argyrodes elevatus, Argiope argentata (both natives).

Group **D1** with as indicator species Argyrodes elevatus (native), Metepeira desenderi and Lycos spec C (endemics).

4° End group D1a : The littoral zones of Santa Cruz, Sierra Negra and the borders of the inner lake of Beagle Crater, with Tivyna spathula, Gasteracantha servillei, Coleosoma floridanum (natives) and Lycos spec C (endemic) as indicator species.

5° End group **D1b** : comprises a coastal arid zone along the NWestern coast of Santa Cruz, the flanks of Beagle Crater (Darwin) and a zone at c. 200m and between c. 550-900m along the eastern flank of Alcedo. Indicator species are Meioneta arida and Neoscona cooksoni (endemics).

Group D2 with as indicator species Anyphaenoides pacifica and Camillina galapagoensis (endemics).

6° End group D2a : a dry zone which seems to be characteristic for the western flank of Darwin between c. 200 and 1200m of altitude. The topzone and coastal arid zone of Wolf have a comparable spider fauna as a zone near 400m of altitude along the eastern flank of Alcedo. There seems to be no comparable zone on Santa Cruz. Indicator species are Metacyrba insularis and Anyphaenoides pacifica (endemics).

7° End group D2b : comprises the top zone of Cerro Azul (c. 1300-1650m), Darwin (c. 1200-1300m) and Wolf (c. 1600m); These zones are situated above an inversion line at about 1000-1100m of altitude ; from there onwards to the top the vegetation becomes more xerophytic again and is characterized by the presence of plant species (e.g. Opuntia-cacti) typical for the low altitude arid zone. This end group also comprises the dry season deciduous steppe forest near 200m of altitude of Cerro Azul, the dry arid coastal area of Alcedo and the open/semi-open dry deciduous forest of the northern flank of Santa Cruz between c. 50 and 300m.

Indicator species are Latrodectus apicalis, Meioneta arida and Meioneta

Table 1. The frequency of occurrence of the indicator species in the 7 habitat end groups as obtained and interpreted from the TWINSPAN analysis (.= absent; 1= occurring in 1-20% of the sampling sites included; 2= 21-40%; 3= 41-60%; 4= 61-80%; 5= 81-100%). The species order is derived from the TWINSPAN classification. The numbers before each species are those used in Fig. 1. Species endemic to the Galàpagos are marked by an asterix.

End Group	D1a	D1b	D2a	D2b	H1a	H1b	H2	
number of localities	8	12	17	13	16	14	18	
1. Metacyrba insularis Banks	2	.	3	.	.	1	.	*
2. Anyphaenoides pacifica (Banks)	.	.	5	2	1	.	1	*
3. Theridion coldeniae Baert & Maelfait	2	3	3	3	.	.	.	*
4. Tivyna spathula (Gertsch & Davis)	4	1	2	2	.	.	.	
5. Argyrodes elevatus Taczanowski	4	4	1	1	.	.	1	
6. Metepeira desenderi Baert	4	4	1	.	.	1	.	*
7. Argiope argentata (Fabricius)	4	4	3	2	.	.	1	
8. Latrodectus apicalis Butler	2	2	.	3	2	.	.	*
9. Meioneta arida Baert	.	4	.	2	.	.	1	*
10. Neoscona cooksoni (Butler)	3	5	3	4	2	2	1	*
11. Gasteracantha servillei (Guérin)	4	1	1	.	1	.	1	
12. Camellina galapagoensis (Banks)	1	1	3	3	2	2	1	*
13. Coleosoma floridanum Banks	4	.	2	3	3	4	1	
14. Lycosidae spec C	5	1	1	.	1	.	4	*
15. Meioneta galapagosensis Baert	.	.	1	2	1	2	4	*
16. Leucauge bituberculata Baert	.	.	2	1	4	4	1	*
17. Coryssocnemis conica Banks	.	.	.	1	1	5	.	*
18. Laminacauda dentichelis Millidge	.	.	.	.	1	5	.	
19. Lycosidae spec D	.	.	.	.	.	4	.	*
20. Neocautinella ochoai Baert	.	.	.	1	2	5	3	*
21. Notiohyphantes excelsa (Keyserling)	.	.	.	.	.	3	2	

There is a great resemblance in spider faunal composition between Santa Cruz and V.Sierra Negra. The variation in vegetation from coast to summit on the S slope of V. Sierra Negra is also comparable to that on Santa Cruz. V. Sierra Negra is the only Isabela volcano which is inhabited by man who altered the fertile mid-zone (300-500m) - former Scalesia zone (cfr. Santa Cruz) - into a farm zone with cultivated fields, pastures, farmland, etc. As on Santa Cruz we find moreover only on V. Sierra Negra habitats as lagoons, coastal marshy areas and a typical summit fern-sedge (pampa) zone. Such situations are not present or only poorly developed on the other Isabela volcanoes.

67% of the indicator species are endemics.

Discussion

The segregation of the sampling sites based on their spider fauna into habitat groups was more subtle for the island of Santa Cruz where these habitat groups coincide with the botanically recognized vegetation zones. Santa Cruz has a clearly delimited *Scalesia*-wood and *Miconia* zone (both absent on the Isabela volcanoes) while the arid zone could be further differentiated in different subzones (BAERT et al., subm. paper). The variation in vegetation from coast to summit on the S slope of Sierra Negra is comparable to that found on Santa Cruz. A similar pattern of variation in vegetation structure and composition can also be found on the other volcanoes of Isabela, but some of them rise to higher elevations and there display peculiar vegetation types. Such areas are mostly arid which is related to the fact that the upper limits of the cloud layer are for a large part of the year below the tops of the volcanoes (inversion zone) (HAMANN,1981).These differences in vegetation differentiation between Santa Cruz, V. Sierra Negra and the other Isabela volcanoes can be explained by the history of the formation of the islands and volcanoes of the archipelago and by their position within the complex climatology of the archipelago. The climate of the archipel is, due to its isolation, determined by the ocean currents which bathe it. The rainfall is concentrated on the southern and eastern slopes of Santa Cruz, V. Sierra Negra and Cerro Azul. The peculiar vegetation types developed on Cerro Azul are the result of the peculiar climatic conditions due to its extreme steepness.
The northern Isabela volcanoes have a drier appearance, as they receive less rainfall.
Based on a formula given by COX(1983) we estimated the approximative age of each volcano. Using the sequence of origin as given by NORDLIE(1973) we obtained : V. Cerro Azul (c. 0.3my), V. Wolf (c. 0.3my), V. Darwin (c. 0.4my), V. Alcedo (c. 0.8my) and V. Sierra Negra (c. 1.3my). The age of Santa Cruz has been estimated (age measurements of old lava rocks) at 4.2my. The volcanic inactivity of Santa Cruz and V. Sierra Negra has permitted the formation of a well developed soil together with the stabilisation of the vegetation into vegetation associations (zones) according to the changing climatic conditions with altitude. The various spider species could also adjust their altitudinal distribution according to their preference for the prevailing environmental conditions. The volcanoes Cerro Azul, Alcedo, Darwin and Wolf are relatively younger and are still in a younger volcanic evolutive stage (still active from time to time). Their soil is not yet as well developed and the differentiation of their vegetation in different zones, as a function of changing climatic conditions with altitude, is very gradual (only a shift in dominance of certain plant species is visible). This may explain the uniformity of the spider fauna over a long altitudinal distance along the slopes of the three northern Isabela volcanoes.

The species colonizing (by chance) the islands must have high adaptive properties to survive the harsh climatic conditions of the arid zone. Of the 55 species involved in our analysis, indeed 73% live in dry situations, either almost exclusively in the dry habitats (42%), either preferring dry conditions but able to survive in humid habitats (13%) or thriving in humid habitats but also occurring in dry situations (18%). So in conclusion, we can say that the spider communities of these islands can be related not only to the availability of different habitats and vegetation zones, but also to the extent of human influences and cultivation, as well as to the age of these islands and volcanoes corresponding to the degree of ecological maturation of different communities.

References

BAERT, L. & MAELFAIT, J.-P. - 1986 - A contribution to the knowledge of the spider fauna of Galápagos (Ecuador). Bulletin de l'Institut royal des Sciences Naturelles de Belgique : Entomologie, 56: 93-123.

BAERT, L., DESENDER, K. & MAELFAIT, J.-P. (submitted paper) - Spider communities of Isla Santa Cruz (Galápagos - Ecuador). Journal of Biogeography.

BAERT, L., MAELFAIT, J.-P. & DESENDER, K. - 1989a - Results of the Belgian 1986-expedition : Araneae, and provisional checklist of the spiders of the Galápagos archipelago. Bulletin de l'Institut royal des Sciences Naturelles de Belgique : Entomologie, 58: 29-54.

BAERT, L., MAELFAIT, J.-P. & DESENDER, K. - 1989b - Results of the 1988-expedition to the Galápagos islands : Araneae. Bulletin de l'Institut royal des Sciences Naturelles de Belgique : Entomologie, 59: 5-22.

COX, A. - 1983 - Ages of the Galápagos islands. Pages 11-23 In R.I.Bowman, M.Berson and A.E.Leviton, eds.Patterns of Evolution in Galápagos organisms. Pacific Division, AAAS, San Francisco, California.

HAMANN, O. - 1981 - Plant Communities of the galapagos Islands. Dansk Botanisk Arkiv, 34(2): 1-163.

HILL, M.O. - 1979a - DECORANA : a FORTRAN program for detrended correspondence analysis and reciprocal averaging. Section of Ecology and Systematics, Cornell University, Ithaca, New York, 30pp.

HILL, M.O. - 1979b - TWINSPAN : a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Section of Ecology and Systematics, Cornell University, Ithaca, New York, 48pp.

NORDLIE, B.E. - 1973 - Morphology and structure of the western Galapagos volcanoes and a model for their origin. Geological Society of America Bulletin, 84: 2931-2956.